AH

(12) UK Patent Application (19) GB (11) 2 333 665 (13) A

(43) Date of A Publication 28.07.1999

(21) Application No 9801439.2

(22) Date of Filing 24.01.1998

(71) Applicant(s)
GPT Limited
(Incorporated in the United Kingdom)
PO Box 53, New Century Park, Telephone Road, COVENTRY, CV3 1HJ, United Kingdom

(72) Inventor(s)
Neil Andrew McDonald
Melvin Paul Clarkson

(74) Agent and/or Address for Service
Andrew Walker
GEC Patent Department, Waterhouse Lane, CHELMSFORD, Essex, CM1 2QX, United Kingdom

(51) INT CL^6
G06K 7/08 // G06K 19/07

(52) UK CL (Edition Q)
H4L LACF
G4M MB3 MCF

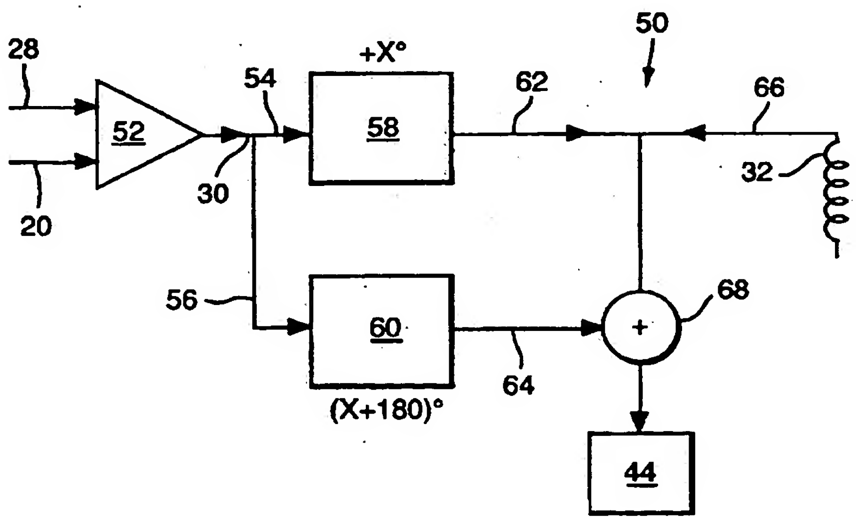
(56) Documents Cited
GB 2291725 A **GB 1500289 A** **EP 0677815 A2**
EP 0651539 A1

(58) Field of Search
UK CL (Edition P) **G4M MCD MCF , H4L LACF LANG LANX LAX**
INT CL^6 **G06K 7/08 19/07**
Online: WPI

(54) Abstract Title
Transaction system

(57) A transaction system comprises a terminal and a contact less token which communicate over an inductive coupling. Power and data are transmitted by the terminal to the token by a carrier signal. The token modulates the carrier signal by drawing more power from the signal. Data receiving means receives a first and second carrier signal, the first carrier signal being a version of the original carrier phase shifted 58 by +X° and the second carrier signal being a version of the original carrier shifted 60 by (X+ 180)°. The first carrier is transmitted by the terminal and a signal containing the first carrier and the modulated signal from the token and the second carrier are summed 68 to produce a data signal. The token may be a smart card.

Fig.2.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

GB 2 333 665 A

Fig.1.

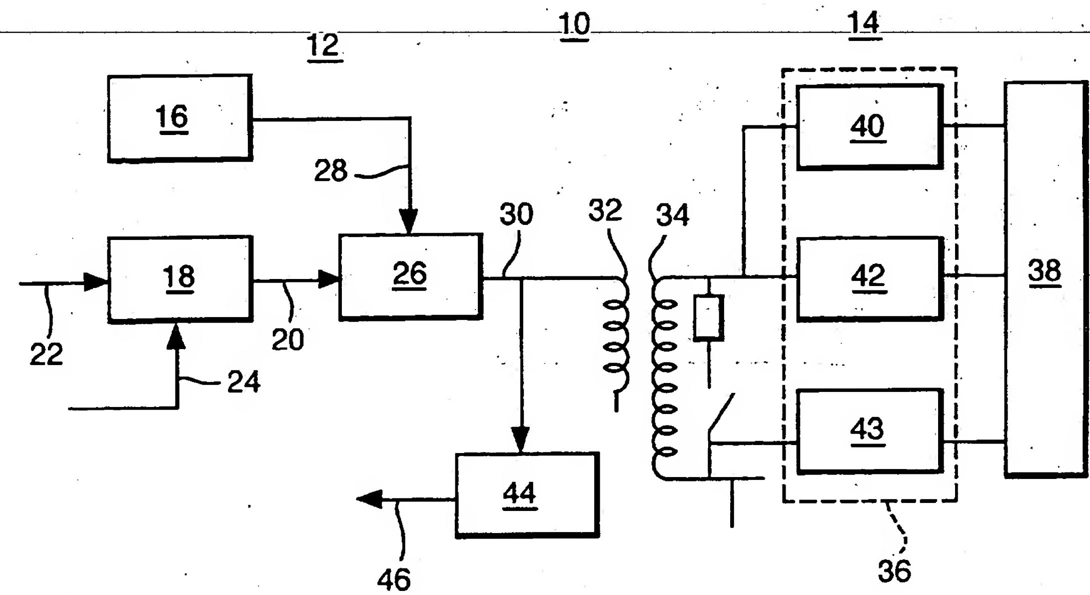

10
12
14
16
18
26
28
30
32
34
22
20
24
40
42
43
38
44
46
36

Fig.2.

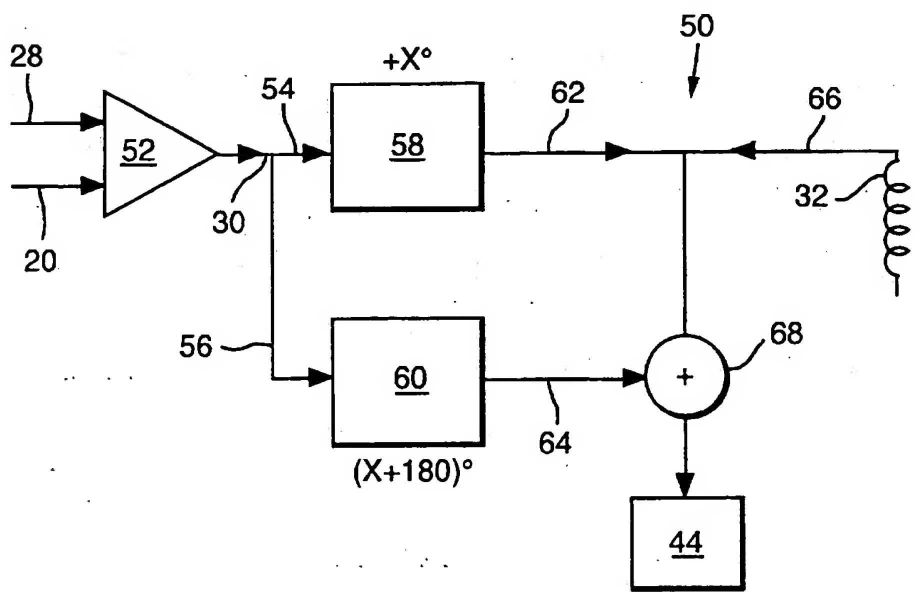

28
52
20
30
54
+X°
58
62
50
66
32
56
60
64
(X+180)°
+
68
44

Fig.3.

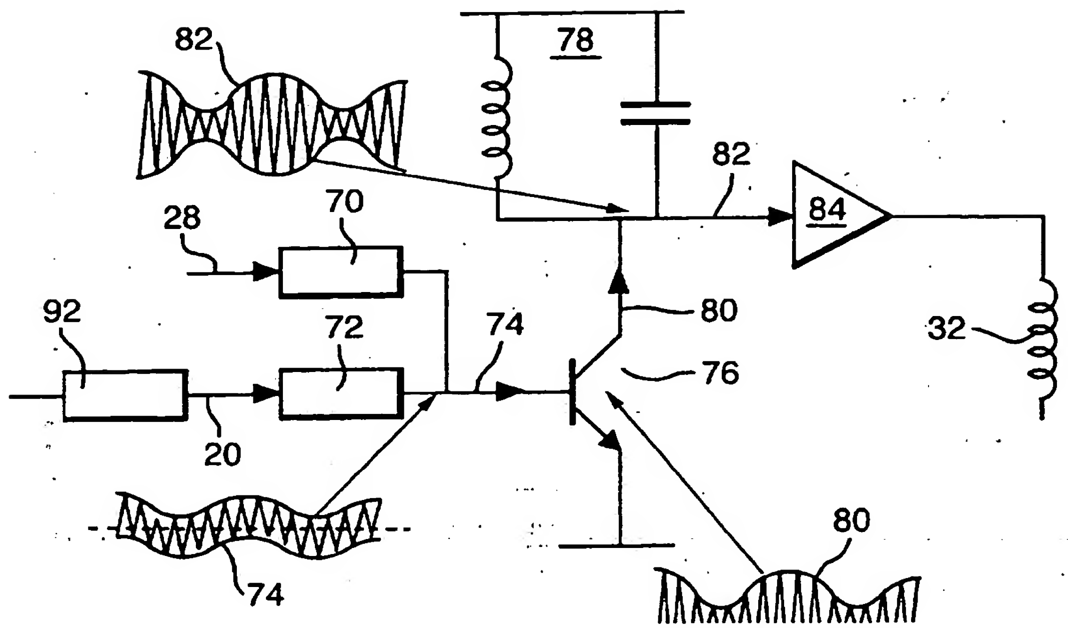
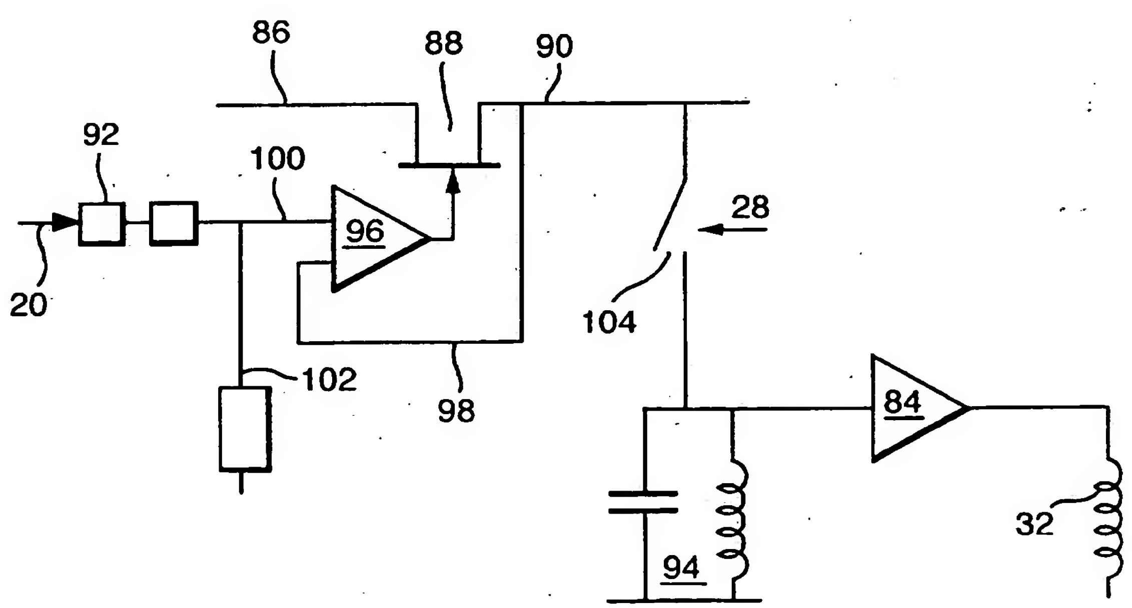

82
78
82
84
28
70
92
72
74
80
76
32
20
74
80

Fig.4.


86
88
90
92
100
96
28
20
104
102
98
84
32
94

2333665

TRANSACTION SYSTEM

This invention relates to a transaction system in which a portable token, for example a card, is used in conjunction with a device, often termed a terminal, to perform a transaction of some kind. The invention is particularly, but not exclusively, related to smart cards.

Contactless tokens work on, or close to, a terminal which provides power. This power is supplied via a RF (radio frequency) induction field which is referred to as a carrier signal which is transmitted from the terminal to the token. Transfer of power from the terminal to the token is akin to the terminal being a primary coil of a transformer and the token a secondary coil. In particular embodiments both the terminal and the token typically each have a single coil aerial

As well as power being transmitted from the terminal to the token on the transmitted carrier signal, data is transmitted from the terminal to the token and vice versa. Exchange of the data is used to perform a transaction. Transmission of data from the terminal is straightforward because it is simply modulated onto the carrier signal before it is transmitted. Transmission of a data signal from the token to the terminal may be effected by switching an impedance in the token to modulate the amplitude of the carrier signal at the terminal as the token draws extra power from the terminal due to the switching action. Data receiving means in the terminal derives the data signal sent by the token by detecting a variation in amplitude of the carrier signal in the terminal.

As technology improves power consumption of tokens is being reduced. This means that tokens can work further away from the terminal, that is the volume or field of operation of the terminal is larger.

A problem in such systems is that the amplitude of the data signal from the token received by the terminal is weak in comparison to the amplitude of the carrier signal. If the terminal modulates another signal onto the carrier signal, such as a tone which is to be used by the token to derive a clock, the data signal will be weak in comparison to this other signal as well. The weakness of the data signal is a problem because the carrier signal from the terminal is being transmitted at the same time as the data signal from the token and the token and the terminal each have only one aerial. Therefore, the signals are both present at the reader aerial. As the token is powered further from the terminal, the power level of the carrier signal remains approximately the same and the power level of the data signal at the reader aerial decreases. Therefore, the ratio of the received data signal to the carrier signal becomes lower as the token moves away from the terminal aerial. Typically the ratio of the data signal to the carrier signal is less than 1%. As the desire for communication between tokens and terminals at even larger separations increases this problem becomes worse.

One solution is to avoid simultaneous transmission of the carrier signal from the terminal and the data signal from the token. To do this it is necessary for the terminal to transmit to the token and then turn itself off whilst it tries to detect the data signal from the token. However, many modern contactless tokens contain a controller which

needs to be permanently powered. For the controller to be powered at times when the terminal is not transmitting the carrier signal, the token requires energy storage means, such as a large capacitor. Such capacitors are expensive, they take up space and are prone to mechanical damage, especially if the token is in the form of a thin card.

Another solution is to provide the token and the terminal each with two aerials, one to transmit and one to receive. However, a single coil or aerial configuration for each of the terminal and the token is preferred because this enables the terminal and the token to communicate to each other in any orientation. This provides advantages in simplicity and compactness, particularly for the token.

According to a first aspect the invention provides a transaction system comprising a terminal having an inductive coupling and a token for communicating with the terminal the token having an inductive coil for receiving from the terminal a carrier signal to provide power to the token the inductive coil also transmitting data to the terminal the terminal being provided with data receiving means which receives data from the token characterised in that the data receiving means receives a first carrier signal and a second carrier signal the first and second carrier signals being out of phase so as to reduce substantially the level of the first carrier signal at the data receiving means such that the data can be readily detected.

Preferably the carrier signal is an original carrier signal generated in the terminal. It may be generated using a modulator in the terminal. Conveniently the first carrier signal

is transmitted to the token. Preferably the first carrier signal is created by modifying the carrier signal. Preferably the first carrier signal is created using a low pass filter. Conveniently the second carrier signal is created by modifying the carrier signal. Preferably the first and second carrier signals are substantially 180° out of phase. Preferably the first and second carrier signals cancel each other out.

Preferably one or more phase shifters are used to generate the first and second carrier signals. Conveniently one or more filters is used. Preferably first filter means is used to generate the first carrier signal and second filter means is used to generate the second carrier signal. The first filter means may comprise a low pass filter in the terminal. It may filter out harmonics from the carrier signal to produce the first carrier signal.. These harmonics may originate from a clock signal which is used to generate the carrier signal. The second filter means which is used to produce the second carrier signal may comprise a high pass filter in the terminal.

The first filter means may be arranged so as to induce a phase shift in the first carrier signal. In this event, in order to obtain mutual cancellation of the first and second carrier signals, if the first carrier signal has been phase shifted by x°, the second filter means is designed to induce a phase shift of (x+180)° in the second carrier signal, so that the first carrier signal and the second carrier signal are substantially completely out of phase.

In another embodiment in order to achieve mutual cancellation, that is a relative phase

shift of 180°, one or more all pass filters may be used instead. Alternatively band pass filters may be used.

Preferably the terminal is also able to cancel another signal or other signals present on the carrier signal such as a tone signal which is used to provide a clock on the token. In this embodiment, the tone signal is independent of the carrier signal itself.

Preferably the terminal and the token have a common inductive coupling which is used to transmit from the terminal to the token and vice versa. The coils of the terminal and the token may each have one or more turns. Conveniently both the terminal and the token each have only one coil aerial.

According to a second aspect the invention provides a terminal according to the first aspect of the invention.

According to a third aspect the invention provides a method of reducing the level of the first carrier signal at the data receiving means according to the first aspect of the invention.

According to a fourth aspect the invention provides a method of modulating a carrier signal used in a transaction system which comprises a terminal having an inductive coupling and a token for communicating with the terminal the token having an inductive coil for receiving from the terminal a carrier signal the carrier signal providing power

to the token and transmitting data to the terminal the terminal generating and using a carrier source signal to generate the carrier signal characterised in that the method comprises the steps of adding together the carrier source signal and a modulating signal to produce a summed signal rectifying the summed signal to produce a rectified summed signal and then processing the rectified summed signal to produce a modulated carrier by mirroring the rectified summed signal.

According to a fifth aspect the invention provides a transaction system and/or a terminal which uses the method of the fourth aspect of the invention.

Preferably the summed signal is rectified by sending it through a transistor. Preferably the transistor is a switch for a tank circuit. Preferably the tank circuit fills in the missing half of the rectified summed signal. The tank circuit may also remove harmonics which are present.

According to a sixth aspect the invention provides a method of modulating a carrier signal used in a transaction system which comprises a terminal having an inductive coupling and a token for communicating with the terminal the token having an inductive coil for receiving from the terminal a carrier signal the carrier signal providing power to the token and transmitting data to the terminal the terminal generating and using a carrier source signal to generate the carrier signal characterised in that a modulating signal is applied to a power supply which provides power to a tank circuit which modulates the carrier source signal.

According to a seventh aspect the invention provides a transaction system and/or a terminal which uses the method of the sixth aspect of the invention.

According to an eighth aspect the invention provides a transaction system comprising a terminal having an inductive coupling and a token for communicating with the terminal the token having an inductive coil for receiving from the terminal a carrier signal to provide power to the token the inductive coil also transmitting data to the terminal characterised in that a source signal used to produce the carrier signal is passed through a band stop filter the filter being arranged so as to filter at least one frequency being substantially equal to at least one frequency of the data transmitted by the token.

Preferably the source signal is a modulation signal which is used to modulate a carrier source signal.

According to a ninth aspect the invention provides a method of filtering a carrier signal according to the eighth aspect of the invention.

Preferably the filter removes data or clock harmonics or both from the source signal.

An embodiment of the invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 shows a schematic representation of the transaction system;

Figure 2 shows a transmitter and receiver circuit in the terminal;

Figure 3 shows a modulation circuit in the terminal; and

Figure 4 shows an alternative modulation circuit in the terminal.

In known contactless transaction systems it is usual for a carrier signal modulated with data to pass through a power amplifier in a terminal and then be sent directly to an aerial in the terminal for transmission. In addition the terminal aerial is directly connected to a data receiving means such as a data receiving circuit to receive a data signal which has been modulated onto the carrier signal by a token. The data receiving circuit has to separate a very weak data signal, typically 2mV, from a carrier signal, typically 15V. Because the frequencies of the carrier signal and sidebands containing the data signal are close, it is difficult for the data receiving circuit to demodulate out the data signal. In certain embodiments of transaction systems the frequency of the carrier signal is detected and used by the token to derive a clock for the token. In other embodiments of transaction systems the carrier signal is additionally modulated with a tone signal which is received by and used by the token to generate a clock. Such a transaction system is described in GB patent application 9706019.8. Although the tone signal is not as strong as the carrier signal, it is still considerably stronger than the data signal from the token, typically 1.5V. The tone signal can cause further difficulty in the terminal receiving the data signal because it is generally much closer in frequency to the frequency of the data signal.

Figure 1 shows a transaction system 10 comprising a terminal 12 and a token, such as a smart card, 14. The terminal 12 has a carrier source 16 and a modulation source 18.

The modulation source 18 produces a modulation signal 20 which is a data signal. The modulation signal 20 may contain raw data 22 such as transaction related information and instructions. It may also contain a clock signal 24. The clock signal may be present as a tone which is modulated by the raw data 22. A carrier modulator 26 uses the modulation signal 20 to modulate a carrier source signal 28 produced by the carrier source 16. As a result the carrier modulator 26 produces a modulated carrier signal 30 which is transmitted by an aerial 32 to be received by the token 14.

The token 14 has an aerial 34 and an interface 36 which is connected to a controller 38 such as a microprocessor. The aerial 34 receives the modulated carrier signal 30 and from it the interface 36, and thus the controller 38, extracts a clock and a data signal 40 and power 42. The controller 38 processes the data signal 40 to produce its own data to be transmitted to the terminal 12 to conduct a transaction.

Transmission of data from the token to the terminal is carried out by switching an impedance 43 across the aerial 34 and thus changing the amount of power drawn by the token 14 from the carrier signal of the terminal 12. The terminal 12 receives a signal representative of the impedance switching and detects the token data in data receiving means or a detector 44. Extracted data 46 is then processed by the terminal 12.

Figure 2 shows particular detail of the system of Figure 1 and shows a transmitter and receiver circuit 50 in the terminal. The circuit 50 transmits power and data and receives data. The modulation signal 20 and the carrier source signal 28 are both received by a

power amplifier 52 such that the carrier source signal 28 is modulated by the modulation signal 20. As a result the power amplifier 52 produces the modulated carrier signal 30. The modulated carrier signal 30 is split into two signals 54 and 56, one of which is fed into a low pass filter 58, the other of which is fed into a high pass filter 60. Alternatively it could be fed into an all pass or a band pass filter.

In passing through the low pass filter 58 the phase of the signal 54 (and of its sidebands) is shifted by x° (typically -120°) to produce phase shifted signal 62. In addition the filter 58 attenuates harmonics of the transmitted carrier signal thus helping compliance with RF interference regulations. In passing through the high pass filter 60 the phase of the signal 56 (and its sidebands) is shifted approximately by (x+180)° to produce phase shifted signal 64. The frequency of the carrier signal does not vary and the person skilled in the art would readily be able to design the filters 58 and 60 to provide the desired phase shifts at the carrier signal frequency.

The phase shifted output 62 is used to drive the aerial 32. Since there is only a single aerial 32, not only does this receive the phase shifted signal 62 but it also receives a data signal 66 from the token 14. Conventionally the detector 44 receives a mixture of amplified modulated carrier signal 30 and received data signal 66. The modulated carrier signal 30 is much greater in magnitude than the data signal 66 and so the data signal 66 is usually difficult to detect. This difficulty increases as the token 14 is located further away from the terminal 12. However, in the present embodiment of the invention, the detector 44 receives a summation 68 of signals 62, 64 and 66. As signals

62 and 64 substantially cancel at summation 68 their magnitude is significantly reduced. However, data signal 66 is unaffected by this cancellation and therefore the ratio of the data signal 66 to the signal 62 (which is transmitted as the carrier signal) is greater than in prior art devices making it easier to detect the data signal 66 in the detector 44. The extraction of the data signal 66 from the output of summation 68 is then relatively straightforward to achieve.

The circuit 50 of Figure 2 can readily be incorporated into the terminal 12 of Figure 1. The power amplifier 52 serves as the carrier modulator 26 and has the same inputs 20 and 28. The additional features of circuit 50 can be accommodated to provide a single output to the detector 44.

The transaction system described above produces a modulated carrier signal to send information, such as transaction data or a clock or both, to the token. Amplitude modulation of the carrier signal is often used. One known way of applying amplitude modulation is to add sidebands containing information (such as transaction data or a clock or both) to the carrier signal and then amplify the modulated carrier signal. Another way is to multiply the modulation signal with the carrier source signal as it is being produced. This can be done by feeding the modulation signal directly into the input of a power amplifier such as power amplifier 52 in Figure 2.

A method of modulating the carrier signal according to an aspect of the invention will now be described in relation to Figure 3. This method can be used in a transaction

system having the inventive aspects of Figures 1 and 2 or it may be applied to prior art systems on its own without these aspects. A carrier source signal 28 and a modulation signal 20 are added together by using two resistors 70 and 72. The modulation signal 20 is generated by a crystal oscillator and typically has a frequency of 13.56 MHz. The relative strengths of the signals 20 and 28 are adjusted by the resistors 70 and 72 having predetermined values which obtain the desired proportional relationship. For example, signal 28 could be at 10V and signal 20 at 1.5V. This is not amplitude modulation but is rather a summation. The signals 20 and 28 add together to produce a combined signal 74 which is fed into a transistor 76 which controls a tank circuit 78. A tank circuit is a tuned circuit for storing charge which usually comprises a capacitor and an inductor. If bias levels of the transistor 76 are set correctly, the base/emitter diode of the transistor 76 will cut off half of the combined signal 74 to produce signal 80. The tank circuit 78 then uses signal 80 to produce a mirror image resulting in an amplitude modulated signal 82. The signal 82 is then amplified by power amplifier 84 and supplied to the aerial 32. Alternatively, if of sufficient magnitude, the signal 82 could be applied directly to the aerial 32.

An alternative method of modulating the modulation signal 20 onto the carrier source signal 28 is to modulate directly a power supply which powers a circuit producing the carrier signal. A means of doing this is shown in Figure 4. A steady power supply 86, for example 12V, feeds a FET 88 to produce a regulated power supply 90. This in turn supplies power to a tank circuit 94. The FET 88 is controlled by a high speed operational amplifier 96. As the regulated power supply 90 is fed back to the

operational amplifier 96 by means of feedback link 98, the operational amplifier 96 uses its high gain to maintain power supply 90 close to an input 100. Input 100 is simply a summation of a DC voltage 102 (derived from a bandgap device for example) and the modulation signal 20. Therefore the power supply 90 of the tank circuit 94 has the modulation signal 20 superimposed on it. A switch 104 controlled by the carrier source signal 28 causes the tank circuit 54 to oscillate at the carrier frequency. The tank circuit then produces a carrier signal which has its amplitude dictated by power supply 90 and hence is amplitude modulated.

In the single step methods of amplitude modulation described above the spectral purity of the output, that is the amplitude modulated carrier, is better than in known two step methods. This is because the tank circuit ensures that the fundamental carrier signal frequency at 13.56 MHz is produced but harmonics are not because the tank circuit acts like a tuned circuit and filters them out. These single step methods allow ASK or AM to be used for modulating the carrier signal.

These methods provide a relatively simple way of modulating the carrier signal, that is the power supply to the token.

A further inventive aspect of the transaction system is described below. Again, although it may be applied to the embodiments of Figures 1, 2 and 3 or Figures 1, 2 and 4, it may equally be applied to prior art transaction systems on its own. Data is sent from the token to the terminal using a separate tone at for example 847.5kHz by modulating an

impedance in the token. This frequency is a standard figure which represents a sixteenth of a typical carrier frequency of 13.56 MHz. Since the token data is at a low power level when received at the terminal, any noise at or around this frequency present on a signal being sent to the token, whether it be on the carrier signal or on any data modulating it, will make it more difficult for token data to be detected. Therefore a band stop filter 92 is placed before the carrier modulator 26, 52 so as to filter the modulation signal 20 before it is modulated onto the carrier source signal 28. This removes any components such as clock harmonics at or around this frequency. This filter is shown in Figures 3 and 4. This means that only data transmitted by the token can generate this frequency in the data receiving means. Therefore the data receiving means can be made more sensitive and is therefore able to detect data transmitted by the token when it is relatively far away from the reader terminal.

CLAIMS

1. A transaction system comprising a terminal having an inductive coupling and a token for communicating with the terminal the token having an inductive coil for receiving from the terminal a carrier signal to provide power to the token the inductive coil also transmitting data to the terminal the terminal being provided with data receiving means which receives data from the token characterised in that the data receiving means receives a first carrier signal and a second carrier signal the first and second carrier signals being out of phase so as to reduce substantially the level of the first carrier signal at the data receiving means such that the data can be readily detected.

2. A transaction system according to claim 1 in which the carrier signal is an original carrier signal generated in the terminal.

3. A transaction system according to claim 1 or claim 2 in which the first carrier signal is created by modifying the carrier signal.

4. A transaction system according to any preceding claim in which the second carrier signal is created by modifying the carrier signal.

5. A transaction system according to any preceding claim in which at least one phase shifter is used to generate at least one of the first and second carrier

signals.

6. A transaction system according to claim 5 in which the or each phase shifter is a filter.

7. A transaction system according to any preceding claim in which the first carrier signal is created by using a low pass filter in the terminal.

8. A transaction system according to any preceding claim in which the second carrier signal is created by using a high pass filter in the terminal.

9. A transaction system according to any preceding claim in which the first and second carrier signals are substantially 180° out of phase.

10. A transaction system according to any preceding claim in which the first and second carrier signals cancel each other out.

11. A transaction system according to any preceding claim in which the terminal and the token have a common inductive coupling which is used to transmit from the terminal to the token and vice versa.

12. A transaction system according to any preceding claim in which the terminal and the token each have an inductive coil having one or more turns.

13. A transaction system according to any preceding claim in which both the terminal and the token each have only one coil aerial.

14. A transaction system according to any preceding claim in which the terminal is able to cancel another signal or other signals present on the carrier signal such as a tone signal which is used to provide a clock on the token.

15. A transaction system substantially as described herein with reference to figures 1, 2, 3 and 4 of the accompanying drawings.

16. A terminal for a transaction system according to any preceding claim.

17. A terminal substantially as described herein with reference to Figures 1, 2, 3 and 4 of the accompanying drawings.

18. A method of reducing the level of a carrier signal at the data receiving means in a terminal or a transaction system according to any preceding claim.

19. A method of reducing the level of a carrier signal at a data receiving means in a terminal or a transaction system substantially as described herein with reference to Figures 1, 2, 3 and 4 of the accompanying drawings.

The Patent Office

18

Application No:	GB 9801439.2	**Examiner:**	Glyn Hughes
Claims searched:	1 to 19	**Date f search:**	27 July 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): G4M (MCD, MCF), H4L (LANG, LANX, LACF, LAX)

Int Cl (Ed.6): G06K 7/08, 19/07

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2291725 A	(HALPERN) see page 2 lines 9 - 12	1 - 5, 9, 10, 11
X	GB 1500289	(RCA) see figure 1	1 - 5, 10
X	EP 0677815 A2	(TOSHIBA) see figure 4	1 - 7
X	EP 0651539 A1	(N.V.) see figure 7 and column 4 lines 39 - 56	1, 5, 11, 12

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		